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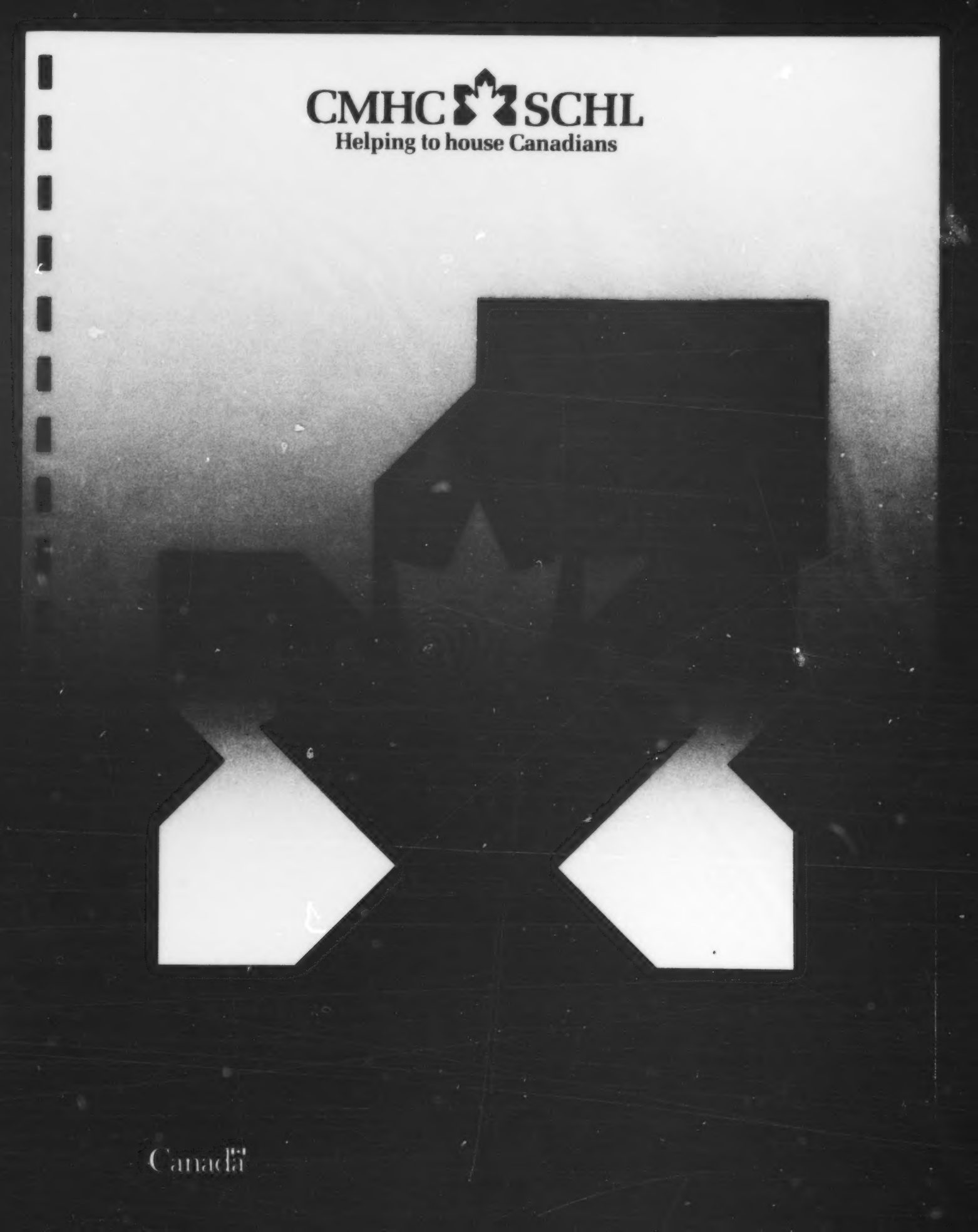

Canada

SMOKE ALARMS AND RESIDENTIAL SPRINKLERS: COSTS AND BENEFITS

APRIL 1991

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Smoke Alarms and Residential Sprinklers

COSTS AND BENEFITS

Summary Report

Smoke Alarms and Residential Sprinklers

Costs and Benefits

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Much of this report summarizes material from two earlier reports prepared for CMHC by A. T. Hansen and R. E. Platts of Scanada Consultants Ltd.:

Analysis of the Cost Benefits of Installing Fire Sprinklers in Houses (June, 1989)

The Costs and Benefits of Smoke Alarms in Canadian Houses (March, 1990)

Many of the values quoted are taken from those two technical studies. They are subject to the qualifications described therein. Readers are advised to refer to the original reports for more details.

The views and opinions expressed and the recommendations made in this report are those of the author and do not necessarily express the opinions of Scanada Consultants Ltd., the Canada Mortgage and Housing Corporation or those divisions of the corporation which assisted in its preparation and publication.

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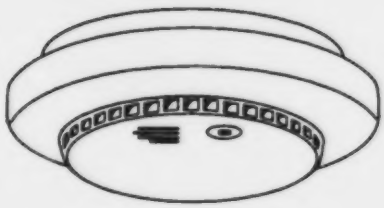

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Introduction: The Issues

Fire fatalities occur most often in the home

Behind all the discussions about this issue lies one fact: a lot of people get injured or die in fires in Canada. In 1987, 277 people (65 per cent of all fire fatalities) died in fires in one- and two-family dwellings across the country – the vast majority of them in homes built before 1980.

This is not surprising, given that "home" is a place where people use heat sources such as matches, cigarettes, stoves, furnaces, portable heaters and various tools. It is also where they become most vulnerable, especially while sleeping, but also after consuming alcohol. And it is where the very young and the very old (both high-risk age groups) spend most of their time.

Some of these deaths are unavoidable with current technology. Anything which might prevent the rest should be examined seriously.

Smoke alarms have improved residential fire safety

As mentioned above, 277 people died in fires in one- and two-family dwellings in 1987. This was a distinct improvement from 1980, when 442 people died. In fact, since the total number of homes had grown, this represents a drop in fire deaths to 4.5 per 100,000 homes in 1987, from 7.9 per 100,000 homes in 1980. There are a number of reasons for this improvement in safety, as discussed on the next pages, but it is generally agreed that one major difference is the advent of inexpensive battery-operated and wired-in-place smoke alarms.

New homes, which have been required by building codes to have mandatory wired-in smoke alarms since early in the 1980's, are much safer (estimated 1.4 deaths per 100,000 houses) than the general housing stock.

Residential sprinklers have the potential to do more

Smoke alarms provide an early warning, allowing people to flee the fire. Residential "fast response" sprinklers can put many fires out – before they get out of control. They respond to heat in about 70 per cent of the time it would take a commercial sprinkler. But they are expensive.

Should sprinklers be installed in new one- and two- family homes?

Fire-fighting groups feel that residential sprinklers present an opportunity to save more lives. They have made many submissions calling for residential sprinklers to be made mandatory in all new houses – initially at the National Building Code level, and recently to provincial and municipal governments as well. They argue that because the new technology has the potential to save lives, reduce injuries and property losses, and decrease growing demands on fire departments, it must be seriously considered as a mandatory requirement in building codes.

On the other hand, those who oppose mandatory sprinklers argue that the fire risk in new one- and two-family homes already has been reduced substantially because of new building materials and systems, and particularly because of mandatory wired-in smoke alarms. They argue that the small amount of remaining risk does not justify the extra cost of installing a sprinkler system in a new home.

New home buyers trying to assess the sprinkler option need objective information. And regulatory authorities also need this information so they can examine sprinklers' costs and benefits to individuals and to society, in order to serve the public interest in the most appropriate way.

How can you accept ANY deaths?

It has been estimated that between 20 and 30 per cent of fire deaths cannot be avoided, because current technology cannot respond to all fire situations and occupant disabilities.

In many of their day-to-day activities, people are constantly

accepting some risk of death. When someone drives a car or allows a child to cross the road by themselves, when they smoke a cigarette, or go swimming and boating, every one of those activities has a risk of accident and death.

As shown in the accompanying chart, the number of people who died in a fire in a new home in 1987 was much lower than the fatalities from many other activities.

Why Cost/Benefit analysis?

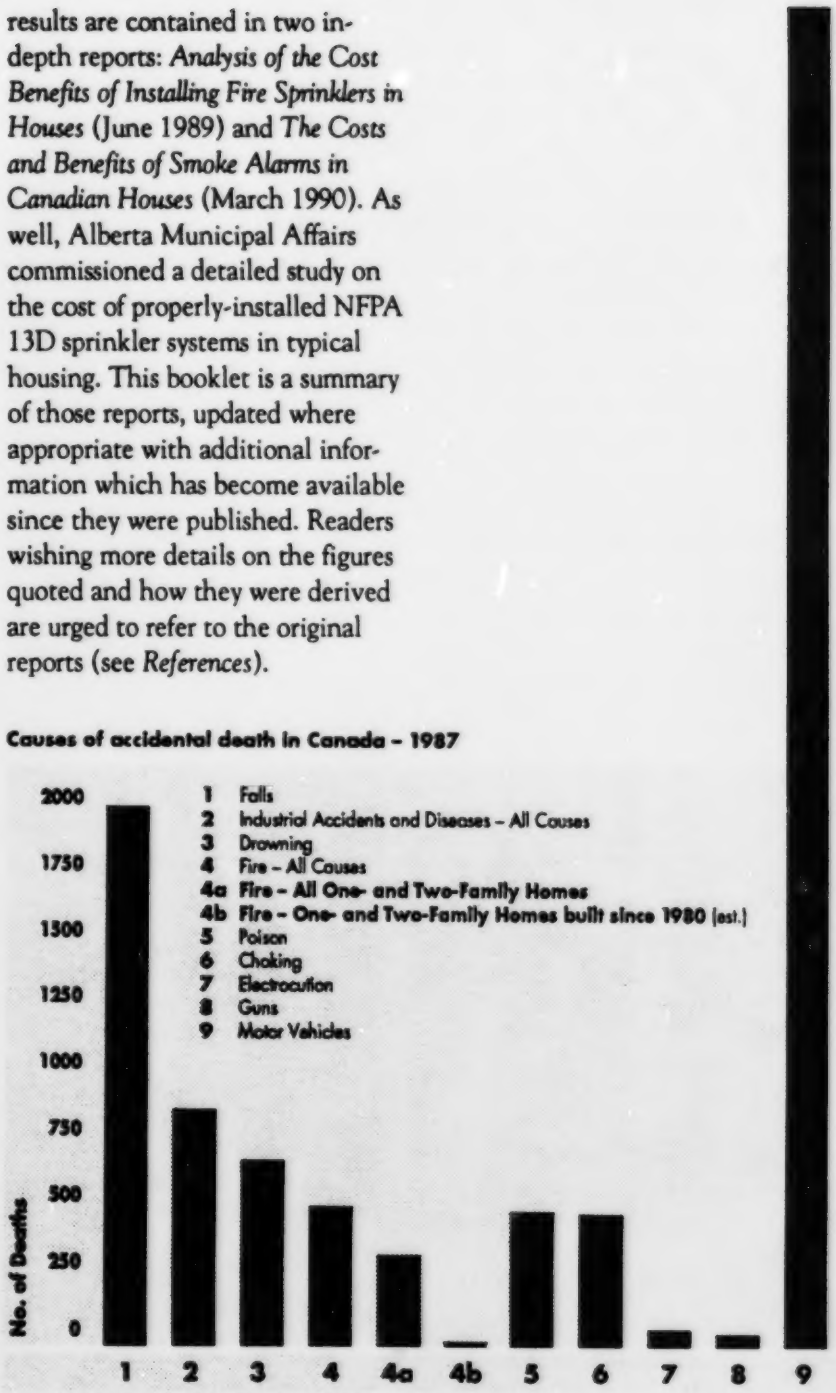
People try to protect themselves, and governments try to protect their citizens. But they need some way to measure which protection options are best for them. Cost/benefit analysis provides a yardstick to compare. It should not be treated as a heartless attempt to value a human life, but as an aid in deciding which alternatives are most worthwhile.

Canadian society has limited resources of capital. If governments are going to mandate where people's money will be spent, they should make very sure it will be used wisely.

CMHC studies offer hard data

In response to the widespread questions surrounding sprinklers and smoke alarms, CMHC commissioned A.T. Hansen and R.E. Platts of Scanada Consultants Ltd. to perform a comprehensive examination of the issues. The results are contained in two in-depth reports: *Analysis of the Cost Benefits of Installing Fire Sprinklers in Houses* (June 1989) and *The Costs and Benefits of Smoke Alarms in Canadian Houses* (March 1990). As well, Alberta Municipal Affairs commissioned a detailed study on the cost of properly-installed NFPA 13D sprinkler systems in typical housing. This booklet is a summary of those reports, updated where appropriate with additional information which has become available since they were published. Readers wishing more details on the figures quoted and how they were derived are urged to refer to the original reports (see *References*).

Causes of accidental death in Canada – 1987

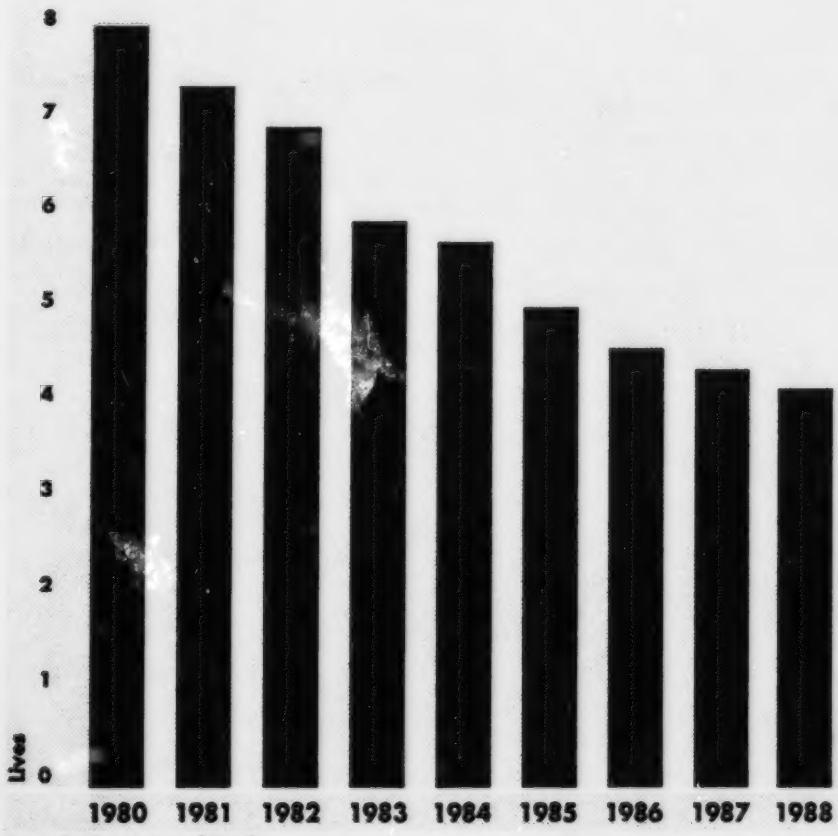


Source: Statistics Canada, Labour Canada and CMHC

Fire Safety Is Improving

Both the overall number of fires in one- and two-family houses, and the rate of fires per house, have been declining in recent years. The number of deaths per fire also has fallen appreciably.

Canadian Fire Losses (One- and Two-Family Houses)
Lives Lost per 100,000 Homes



Source: Fire Commissioner of Canada

While it is difficult to pinpoint with certainty the causes of that improvement, it is widely agreed that the most important single reason is:

- *use of smoke alarms*

Experts in the fire fighting and fire protection industries have called the widespread adoption of smoke alarms "one of the most remarkable fire protection success stories of modern times."

Consumers in both new and existing homes responded enthusiastically as the inexpensive units came on the market. With building code changes early in the 1980's, wired-in alarms have been installed in virtually 100 per cent of new homes built since 1982 (see next section). In those houses built before the mandatory requirement, single station battery-operated smoke alarms proved extremely popular. Statistics Canada has estimated that by 1988 single-station battery-operated smoke alarms had been installed in approximately 80 per cent of all existing houses.

Despite the maintenance problems with battery-operated devices (i.e. ensuring a functional battery), both wired-in and battery-operated smoke alarms appear to have had a considerable impact on the number of fires detected early, and resulted in a sharp reduction in the number of fire fatalities.

Other contributing factors probably include:

- *decreasing number of occupants per household*

Since most fires are caused by occupant activities, it is reasonable to presume that fatalities per dwelling will decrease as the number of occupants decreases.

- *decreasing percentage of smokers*

Reports from various localities show that cigarettes, pipes and matches were the cause of between 35 and 60 per cent of all fatal fires.

- *improved ignition resistance of furniture*

Mattress flammability has been regulated by government in Canada since 1982, and there has been a voluntary program for upholstery fabrics for several years.

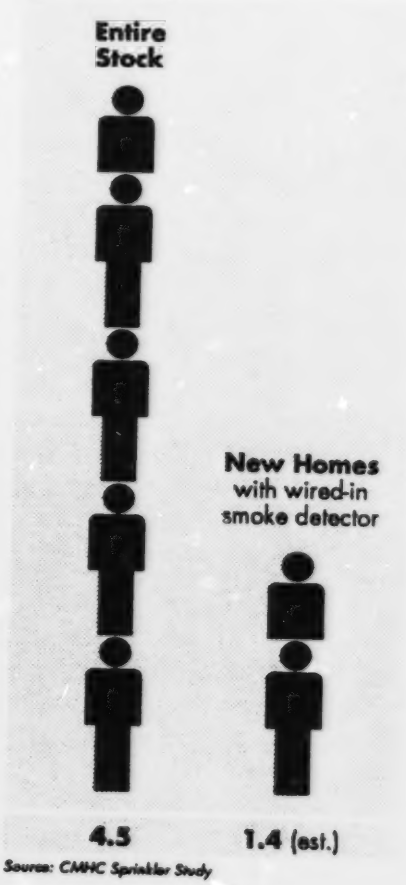
- *improved appliance safety standards*

Various consensus standards, together with appropriate testing and certification, have resulted in improved safety for both large and small appliances.

New Houses are even safer

New one- and two-family houses, with wired-in smoke alarms, are demonstrably safer than the general housing stock. Based on figures from British Columbia, Alberta and Quebec, where fire reports indicate the age of the structure, the CMHC sprinkler study estimated that the fatality rate for the entire housing stock is at least 3.5 times higher than the rate for newer houses.

Fatality Rate per 100,000 Homes Canada – 1987

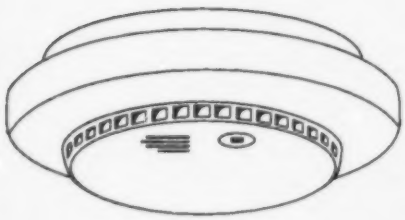


Source: CMHC Sprinkler Study

Will they stay that way?

In addition to the factors noted above, new houses benefit from improved safety of materials, equipment and design (e.g. safer central heating, together with increased energy efficiency, reduces or eliminates the need for dangerous portable heaters or space heaters), as well as stricter fire safety requirements in building codes and higher overall quality of both buildings and inspections. With these advantages, the homes should maintain a high level of safety as they age, assuming an adequate level of maintenance of the structure and the mechanical/electrical systems.

Smoke Alarms: Benefits and Costs



What is a smoke alarm?

A smoke alarm is a unit designed to alert occupants to the presence of smoke/fire. These alarms are activated when smoke either interferes with the ability of ionized air to conduct an electrical current (ionization detectors) or scatters light in a way which affects a photosensitive plate (photoelectronic detectors). This causes an alarm to sound. With early detection of many fires, very small ones can be extinguished before they spread, and residents are given enough time to escape from larger ones. Ionization types of detectors are better at detecting fast flaming fires; photoelectronic types are better at detecting slow smouldering fires, which tend to have larger smoke particles. Both types have proven very effective in residential applications.

How long have they been available?

Stand-alone, battery-powered smoke alarms were introduced in 1970, and manufacturers started heavily advertising affordable products in the mid- to late-70's. In 1980, Canada's model National Building Code required wired-in smoke alarms for all new houses. Most provinces and municipalities quickly adopted the requirement into their respective building codes and, by 1982, virtually all new homes across the country would have been built with wired-in smoke alarms.

For the total stock of new and older housing including townhouses and apartments, Statistics Canada estimates that about 83 per cent of owner-occupied households and 74 per cent of tenant-occupied households were equipped with some form of smoke alarm in 1988.

Benefits to occupants:

- *early warning of products of combustion*. This gives occupants an opportunity to extinguish small fires or flee larger ones. It is also very effective in alerting occupants to smouldering fires, which can produce fatal levels of smoke and carbon monoxide long before they significantly increase room temperatures.
- *can wake sleeping occupants*. The longer a fire goes undetected, the more likely it will get out of control. U.S. data from the first half of the 1980's shows smoke alarms gave first notice of a fire in almost two thirds of cases when everyone was asleep.

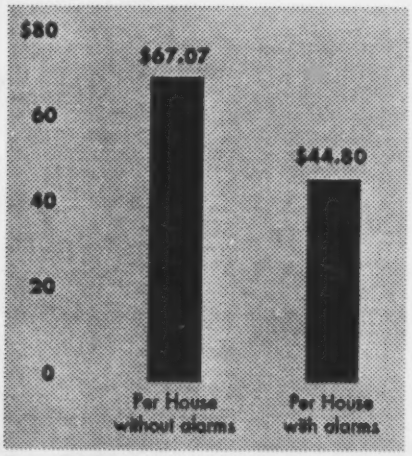
Benefits to society:

Using Canadian data wherever possible, the CMHC sprinkler and smoke alarm studies found that use of smoke alarms led to:

- *a dramatic decrease in fatalities.* Early warning allows occupants to extinguish fires or escape from danger.
- *a slight decrease in injuries.* It appears that people who might otherwise die may instead be injured, causing these figures to stay relatively high.
- *a drop in property loss.* Although average figures for dollar loss per fire appear to have been increasing, adjusting for inflation reveals that they are virtually unchanged since 1980. There is, however, a pronounced drop in real property loss per house. The early warning provided by smoke alarms has likely contributed to a lower number of reported fires. The CMHC smoke alarm study calculates that, assuming new homes (with more expensive materials) have the same loss reduction due to smoke alarms as older homes, the per-house loss without alarms would be appreciably higher than its current level.

During its calculations for the potential benefits of installing smoke alarms in still-unprotected homes, the study touched on the benefits of smoke alarms for the general housing stock, as shown in the charts below.

Estimated Property Damage in New Homes



Source: CMHC Smoke Alarm Study

Drawbacks and Limitations

Battery-operated:

- *dependent on functioning batteries.* U.S. studies suggest about 30 to 35 per cent of alarms in houses with reported fires did not go off – and the largest single cause is removed or non-functioning batteries. If you include all homes (not just those with reported fires), the CMHC studies estimated that about 25 per cent of battery operated alarms probably are not functioning reliably because of this. However, the alarm is no less efficient than a wired-in unit if a good battery is installed. Wired-in alarms are estimated to have efficiencies approaching 97 per cent, excluding disconnection during arson.

Fatalities per 100,000 at various age groupings

Source: Statistics Canada

Fatalities and Injuries

	Fatalities per 100,000 homes	Injuries per 100,000 homes
Existing Homes before alarms	9.2	23.5
Existing homes with smoke alarms (mostly battery-operated)	3.4	20.6
New Homes with wired-in smoke alarms	1.4	20.0

Source: CMHC Sprinkler and Smoke Alarm Studies

Putting battery-operated smoke alarms into 100,000 still unprotected homes could save at least 7 lives per year

All smoke alarms:

■ *safety depends on occupants taking action*. Those who can't do so on their own (very young children, frail elderly, disabled, or impaired) may not be able to take advantage of the early warning because of their restricted mobility. In fact, fire statistics show those under five and over 75 are at the highest risk of dying in residential fires on a per capita basis. People in direct contact with the fire will rarely be able to save either themselves or others.

■ *can't respond to all fire situations*. An explosive fire may move too quickly for smoke alarms to give those in the same room enough time to escape. A smouldering fire in a closed room without a smoke alarm may not cause alarms outside the room to sound until after conditions inside have already become hazardous.

■ *nuisance alarms*. The main reason people disable their own detectors is because alarms go off when there is no fire hazard (especially during cooking.)

■ *depend on owner maintenance*. Standards recommend weekly testing of battery-operated and monthly testing of wired-in smoke alarms. Responsibility for those tests rests with the owner. A 1982 U.S. study said only 40 per cent of alarm owners report they test their units monthly. Ontario Housing Corp. data suggests approximately 2.4 per cent of wired-in units need replacement or servicing per year. The long-term reliability of the detector itself has recently been questioned. Fire officials feel that by the time smoke alarms are 10 years old, 20 to 30 per cent of detectors may no longer be functioning properly.

Costs

The following chart sets out cost estimates for wired-in and battery-operated smoke detectors, as reported in the CMHC and Alberta sprinkler studies and by members of the Canadian Home Builders' Association.

Cost of Typical Smoke Alarm Installations

Wired-in (new house)	average $300 $150 for the circuit and $40 to $45 per unit
Wired-in (existing house)	from $375 (e.g. installing detectors on the wall, and dropping electrical wires down the wall cavity to be wired into existing circuits at the outlet.)
Battery-operated (installed by the householder)	$20/unit (including spare batteries)
Battery-operated (installed by contractor)	up to $40/unit

Source: CMHC Sprinkler Study, based on John C. Wiebe and CHBA

Impact of Installing Smoke Alarms in Still Unprotected Homes

	Basic	Upgrade
Cost per home	$40–80	$80–160
Lives saved per 100,000 homes per year	7	8.5
Property damage avoided per home per year	$45–55	55–60
Cost/life saved	+/– 0	+/– 0

Source: CMHC Smoke Alarm Study

Opportunities for further benefit

■ *install smoke alarms in still-unprotected homes*

About one in six Canadian houses (18 per cent) still does not have any smoke alarms. It is reasonable to speculate that these are also the highest-risk houses, where other socio-economic factors are likely to come into play: low income, low education, and differing cultural awareness of fire risk.

The CMHC smoke alarm study has estimated that the annual fatality rate in these homes is about 13 deaths per 100,000 homes per year – almost three times that of the general housing stock. If two basic battery-operated smoke alarms were installed in these homes, deaths could drop to about 6 per 100,000 homes. A more extensive system with four alarms could bring the fatality rate down to 4.5 per 100,000. On a societal basis, the cost per life saved would be minimal: the units would pay for themselves in reduced property losses within the first one or two years.

■ *promote regular maintenance and testing*

Make sure smoke alarms in existing homes are functioning properly and encourage people to perform regular tests of both the detectors and the batteries. Require a visual "low battery" warning on all battery-operated alarms. Consider a program of periodic inspection of smoke alarms through municipal fire departments, building departments or similar agency.

■ *discourage disabling of smoke alarms*

Use timed "override" switches so occupants can turn off the alarm for a short period of time after false alarms. Use units constructed so that alarm cover cannot be closed unless a battery is installed.

■ *install additional alarms where necessary*

Current standards call for one alarm outside bedroom doors on each level with sleeping rooms. Since a large number of fires start in the living room and basement, further improvements in life safety may be achieved by installing additional smoke alarms in these areas in new and existing homes.

Sprinklers: Benefits and Costs

What is a sprinkler?

A residential sprinkler is a system for in-home fire control. It consists of a water pipe system, including check valves to isolate it from the domestic water system, and special sprinkler heads installed on ceilings or walls. It may also include a water flow alarm. A residential or "fast response" sprinkler system is designed to use lower water pressures and flow rates, and respond more quickly to lower temperatures than commercial sprinkler installations. Each sprinkler head contains a low mass fusible link, which melts at temperatures as low as 165°F, to start the water spraying. To meet current standards, systems must continue spraying for 10 minutes at 18 gallons per minute if a single head is activated, 13 gallons per minute for each of two heads.

How long have they been available?

Sprinkler systems are governed by standards which have been carefully developed and refined over time. In the mid-1970's, commercial sprinkler systems were the only ones available. Standards for commercial systems were both too complicated and too expensive for residential applications, so a separate standard was written for the installation of sprinklers in one- and two-family homes (NFPA 13D). However, it was found that the commercial heads still did not respond adequately to residential needs. In 1979, the National Fire Protection Association in the U.S. began a series of tests on quick response systems, using newly-designed heads, wider spray profiles and plastic piping. After those tests, NFPA 13D was updated to reflect the new technology. The first residential sprinkler head with Underwriters' Laboratory listing became available in 1980: the second in 1982. The standard for quick response residential sprinkler systems in Canada and the U.S. is NFPA 13D.

Benefits to occupants:

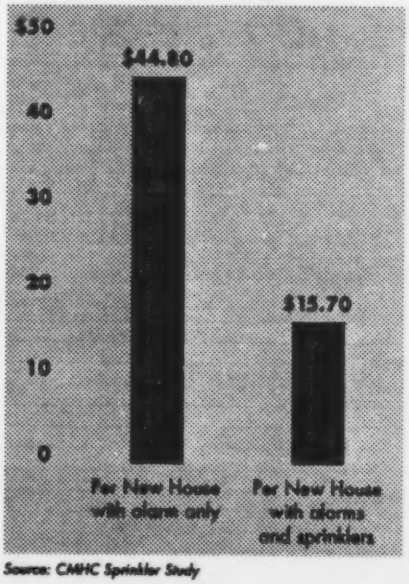
- *early control and suppression of most fires*. As the Alberta report Residential Fire Prevention put it: "the home is transformed into its own 'fire station' in the event of a fire."
- *occupants' safety does not depend entirely on their own actions*. The very young, frail elderly, disabled or impaired, who cannot flee a fire, may receive protection if the sprinkler can extinguish a small fire before it grows. Sprinklers can also help limit fire growth and keep exit conditions tenable for a period of time. (Design flow is 10 minutes.)

■ *potential savings in insurance costs*. Some companies offer a decrease in insurance premiums to reflect lower risks: others do not. In its Report on Sprinklers in Vancouver, MJD & Associates reported that percentage reductions offered in that market ranged up to 15 per cent. For smoke alarms alone, the equivalent reduction was 5 to 10 per cent.

■ *potential trade offs in building code requirements*. Some municipalities in the U.S. have allowed concessions in requirements for fire department access, building materials and design where houses are sprinklered. No similar concessions are available in the National Building Code of Canada. It should be recognized that building codes already set out the minimum requirements to ensure protection for health and safety, and further reductions could place the house at risk if the sprinkler failed to operate, so there are limited opportunities for further benefit. However, some owners may want building codes which allow them to construct homes closer to the lot line, to install windows in restricted locations or to build on lots with restricted fire access if sprinklers are installed.

■ *potential for added protection*. People in direct contact with the fire source may still be unsaveable. However, others may survive if sprinklers are operating properly. So far, there are not enough figures on sprinkler installations in houses to check their reliability. Ongoing maintenance and testing may be a considerable problem in residential applications. In commercial situations where maintenance is a clearly assigned responsibility with regular inspections, sprinkler reliability (responding before hazardous conditions are reached) is estimated at well over 95 per cent. In residential applications, it is assumed that residential sprinklers could reach the same level of reliability, as long as the same level of maintenance is achieved.

Estimated Property Damage



Source: CMHC Sprinkler Study

Fatalities and Injuries

	Fatalities per 100,000 homes	Injuries per 100,000 homes
New Homes with alarms only	1.4	20.0
New Homes with mandatory wired-in smoke alarms and sprinklers	0.63	11.3

Source: CMHC Sprinkler Study

Benefits to society:

The CMHC studies estimated that sprinklering new homes would have the following effects:

- further decrease in fatalities
- significant drop in injuries
- large decrease in property damage

The study's estimates of the benefits of smoke alarms are shown in the accompanying charts.

Sprinklers can turn the home into its own 'fire station' – but they're expensive

■ *possible savings in fire service costs.* Proponents of sprinklers say the lower expected fatalities, injuries and property damage where entire communities are sprinklered should lead to such things as increased hydrant spacing, decreased main sizes, reduced pumping capacity, increased distances between fire stations, reduced number of fire stations and reduced equipment costs. MJD & Associates' Report on Sprinklers in Vancouver points to the very low number (less than two per cent) of total fire department emergency calls which turn out to be fires in dwellings, and concludes that significant decreases in costs are unlikely. The CMHC sprinkler study estimated potential savings at $22 per house per year, and felt even that figure might be overstated. The amount may be cancelled by increased property taxes, if the presence of a sprinkler system increases the house value.

Drawbacks and Limitations

■ *may not respond to some fire situations.* Residential sprinklers may offer advantages, but they are not a panacea. Research seems to indicate even quick-response sprinklers will not start up before smoke and carbon monoxide reach fatal concentrations if the fire starts in a closed unsprinklered room or closet. If a fuel container or a flammable couch suddenly flares up, the person holding the container or sleeping on the couch may not be saveable. A fire which starts in an attic space or closet, or inside the wall cavity, cannot be extinguished by sprinklers installed to NFPA 13D, although they can help protect rooms and halls for a certain length of time. And knowledgeable arsonists can simply disable all fire protection systems.

■ *depend on owner maintenance.* NFPA 13D recommends monthly testing of all valves, as well as visual inspection of sprinkler heads. Responsibility for such maintenance is placed on the owner. As already noted, people are not particularly good at keeping up a regular battery maintenance program for their smoke alarms, a comparatively simple procedure. It is difficult to believe they will be much better with sprinklers, which are more complex.

■ *heads may become inoperative if painted over*. Owners and tenants must be educated to understand how important this could be. Otherwise, the first time they redecorate, they may incapacitate their sprinklers.

■ *installation concerns*. In northern climates, improperly insulated pipes on external walls can freeze, causing damage to the home and system. While installing sprinkler systems in external walls or attics should be no more difficult than installing domestic water pipes, special measures will be required to accommodate ceiling-mounted heads (i.e. extra insulation and boxing).

■ *depend on adequate water pressure*. NFPA 13D is designed to achieve a 10 minute flow at 18 gallons per minute from a single sprinkler head, or 13 gallons per minute for each of two heads. In rural areas and in some infill situations, it may not be possible to achieve the required pressure without special pumps, which add to costs.

Costs

Current costs will vary across the country, given differences in material costs, required connection services and fees. The estimates shown in the chart below are taken from the 1989 Cost Study of Sprinkler Installations, performed by J. C. Wiebe for Alberta Municipal Affairs. They are based on installing a system to meet NFPA 13D in a typical 140 square metre (1,506 square foot) side-split home, with a total sprinklered area of 180 square metres (1,940 square feet), including basement.

As a comparison, prices prepared in 1990 for the Greater Vancouver Home Builders' Association showed an average cost of $3,969 for a 219 square metre house (2359 square feet) — or $18.12 per square metre in that urban location.

Economies of scale could bring production costs for components down somewhat in future. It should be pointed out, however, that most of the cost of a sprinkler system is plumbing and installation, which have limited opportunities for future cost reductions.

Opportunities for further benefit

■ Consider mandating residential sprinkler systems in houses intended for people with physical or mental disabilities

■ Continue research to reduce the costs and improve the cost/benefit of new residential sprinkler systems. An NBC working group has concluded cost is the most important variable in sprinkler cost/benefit evaluation.

Cost of Typical NFPA 13D Sprinkler Installations

Installation	Urban Location		Rural Location	
	Cost	Cost/m²	Cost	Cost/m²
high cost (copper)	$4,599	$25.55	$7,125	$39.58
low cost (plastic)	2,779	15.44	4,792	26.62
average	3,924	21.40	6,313	35.07

Source: J.C. Wiebe

Cost/Benefit Analysis

Societal Perspective

The CMHC Sprinkler Study analyzed the cost/benefits of requiring residential sprinklers in all new one- and two-family homes from a societal perspective: true costs and benefits for the country as a whole. It used a basic model developed by the National Bureau of Standards in the United States, modified as recommended by the National Association of Home Builders and the National Research Council. Risk factors used were those for new Canadian homes, with wired-in smoke detectors.

Instead of assigning a hypothetical value for a life, and then calculating whether the total cost exceeds the benefits, the study determined the net cost of saving a life – which turned out to be at least $38 million.

This figure was then compared to the net cost of saving a life for safety regulations already introduced in the U.S. (based on a report by the U.S. Office of Management and Budget).

Sprinkler Costs, per house per year:	installation cost (annualized)	$318.00
	+ inspection and certification costs	35.00
	+ maintenance and water damage repair	unknown
	Subtotal, greater than	353.00
	Minus	
Total Savings, per house per year:	reduced risk of occupant injuries	$2.61
	+ reduced risk of firefighter injuries	0.90
	+ reduced property loss per house	29.10
	+ reduced indirect costs per house	1.90
	+ reduced fire service costs per house (overstated)	22.00
	Subtotal, less than	56.00
	Equals	
Cost per house per year		$297.00
	Multiplied by	
Reduced risk of fatality		(0.779/100,000 homes)
	Equals	
Cost of Saving One Life		**at least $38,000,000.00**

Source: CMHC Sprinkler Study

Notes:

- **Installation Costs:** With an urban water supply, using plastic pipe, cost would be at least $3,000. Annualized cost is determined using a discount rate of 10 per cent, a term of 30 years and a present worth factor of 9.43.
- **Injuries:** New houses with wired-in smoke detectors but no sprinklers were estimated to have an occupant injury rate of 20/100,000 houses; sprinklered houses to have an injury rate of 11.3/100,000. Reduction is 8.7/100,000. The standard $30,000 cost per injury was used to derive a benefit per house per year of $2.61. Similarly, the reduction in firefighter injuries is estimated as 3/100,000 (6.8/100,000 – 3.8/100,000) x $30,000 equals a benefit of $0.90.
- **Fatalities:** New houses without sprinklers were estimated to have an annual occupant fatality rate of 1.4/100,000; sprinklered houses a rate of 0.63/100,000. Reduction in fatalities is 0.77/100,000. For firefighters, the equivalent figures were 0.016/100,000 (unsprinklered) and 0.007/100,000 (sprinklered) for a reduction of 0.009/100,000. Total benefit of sprinklering, therefore, is 0.779 fatalities/100,000 homes.

Sensitivity Checks

In 1989, a Task Force of the Associate Committee on the National Building Code of Canada looked into the cost benefits of sprinklers in one- and two-family houses. One of its working groups decided to examine the numerous variables in the cost/benefit models to find out which ones had most impact on the final figures. They tried changing the number of fatalities, increasing the assumption of sprinkler effectiveness (in reducing fatality rates, injuries and property damage) and increasing the value of benefits (e.g. value per injury). This exercise showed that installed cost of the sprinkler system is the single most important variable. But even if the cost was reduced to $1,500, the net cost per life saved remained high. These calculations were made to determine sensitivity only; the scenarios were not substantiated by real data or studies.

In the end, the NBC Task Force concluded that a per-house cost of $3,000 or more was not acceptable. Its final report stated that "mandating the installation of sprinklers in houses cannot be justified on an economic basis."

Occupant Perspective

From an occupant's point of view, the most important elements in a decision whether or not to invest in a sprinkler system will be:

- an objective analysis of individual costs
- an objective analysis of the estimated risks, and
- a subjective decision on risk acceptance.

Many of the individual costs are dealt with above. System installation costs are likely to range upwards from $3,000. Maintenance and testing will undoubtedly cost something on an ongoing basis. Owners may be able to qualify for a reduction in insurance premiums, and in taxes relating to fire service costs, but on the other hand property taxes may go up to reflect the increased value of the home.

Estimated risks are also dealt with above. Based on the CMHC studies, for every 100,000 new houses built in Canada, requiring mandatory sprinklers would save almost 0.78 lives. On a per-house basis, the annual fatality figure is very small.

Obviously, for the person in the 0.78/100,000 that could have been protected and wasn't, those figures are not much comfort. However, people considering the investment should also compare their characteristics to the list of occupants considered to be most at risk.

Finally, the decision will be a very personal one.

Perspectives and Comparisons

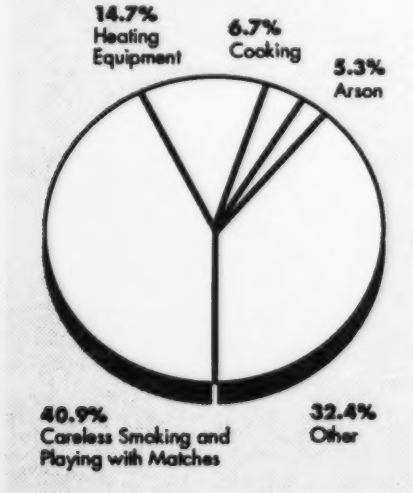
Risks

In 1987, more than twice as many people drowned across Canada as died in fires in all 6.2 million new and existing one- and two-family homes. Almost seven times as many people died from falls and 15 times as many died in motor vehicle accidents. No actual figures are available to measure exactly how many people died that same year in fires in all of the new one- and two-family houses which had been built between 1981 and 1987, but it is likely to have been fewer than 10.

Causes of fires

No statistics are available for Canada as a whole showing the causes of fire fatalities in one- and two-family dwellings, but some individual provinces keep those figures. British Columbia, for example, has data for 1983-88 which shows careless smoking and playing with matches was by far the largest single cause of fire deaths – at 40.9 per cent. The next largest identified cause (14.7 per cent) was heating equipment. (Modern central heating equipment is far more safe than that found in older homes. Portable space heaters, which have been a common cause of house fires, are much less likely to be needed in a new home with energy efficient construction and modern heating.) Cooking was next at 6.7 per cent and arson followed at 5.3 per cent. Excessive drinking is frequently reported to be a factor in house fires.

Causes of Fires
in One- and Two-Family Homes
British Columbia, 1983–1988



Source: Office of the B.C. Fire Commissioner

People at Risk

Occupant characteristics appear to play a large role in fire risk. The highest hazard groups are thought to be:

- smokers and those who live with them
- those who abuse alcohol or drugs
- people living in crowded conditions (by choice or economic necessity)
- the very young (0-4 years), especially if left unattended
- the frail elderly
- physically or mentally handicapped people
- children who play with matches
- households without smoke alarms
- those who do not maintain their fire protection equipment
- those who do not have and practice a fire evacuation plan

Protection options

There are many ways to improve fire safety in the overall housing stock. Other possibilities include:

- smoke alarms in all existing homes
- interconnected alarms in more locations in new homes
- improvements to smoke alarms (nuisance alarm shut-off/low battery warning)
- public education on fire safety and equipment maintenance
- public inspection of alarms
- sprinklers in high-risk occupancies (houses intended for disabled persons)
- fire extinguishers at hazard locations
- dedicated appliance extinguishers (at the stove)
- fire retardant furniture and bedding
- personal emergency alarms for elderly (systems monitored by a specialist company can provide response to various emergency situations like health problems or falls – not just fire)
- child-proof match containers

Comparisons of cost vs other measures

The cost of providing a residential sprinkler system in all new one- and two-family houses could total almost $500 million per year. That is half a billion dollars taken out of the economy – diverted from other things into sprinklers and pipes.

The CMHC sprinkler study estimated it would cost society as a whole $38 million to save one life through a mandatory requirement for sprinklers in all new one- and two-family houses. That figure dwarfs the cost of other life safety measures imposed by governments (see graph).

In comparison, an $80 system of battery-operated smoke alarms could be provided in the 18 per cent of existing houses that don't already have them (1.1 million homes), for less than $100 million. On a societal basis, the cost per life saved approximates zero. The CMHC smoke alarm study estimated that the units would pay for themselves in reduced property losses alone within one year. Reduced injuries and fatalities would be a "free" benefit.

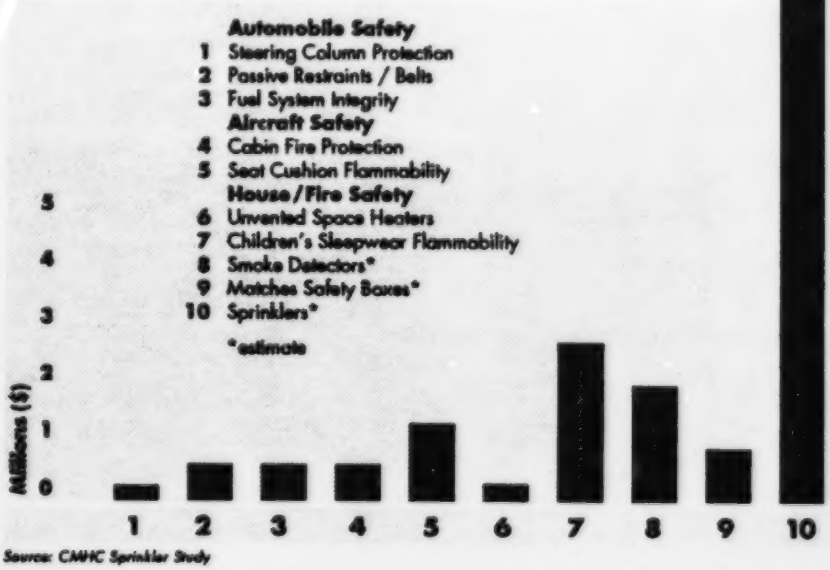
Best use of resources

For the individual new home buyer, it may make more sense to invest in a fire extinguisher, or a monitor system for the children's play and sleep areas, or a personal emergency alarm for an elderly parent – or even swimming lessons – than a residential sprinkler system. For people on the margins of affordability, the extra cost of a sprinkler system may deny them access to a new home.

For society as a whole, it is difficult to justify an expenditure on sprinkler systems for new homes when the cost is substantial while the potential for saving lives is quite small – and when other alternative measures could save more lives much more economically.

Since tolerance for these levels of risk tends to be very personal, the decision whether or not to install a sprinkler system must come down to an issue of personal choice.

Mandatory Regulations – Cost per Life Saved



Source: CMHC Sprinkler Study

Recommendations

Leave residential sprinkler systems voluntary for new one- and two-family houses

Sprinklers are a relatively high cost option for responding to a relatively low risk hazard (see graph). Allow new home buyers to make their own decisions on a voluntary basis.

Protect the 18 per cent of one- and two-family houses that still don't have smoke alarms

There is a significant opportunity to improve the fire safety of the existing housing stock at relatively low cost (see graph). Functional battery-operated smoke alarms should be installed at appropriate locations in all existing one- and two- family homes.

Increase the number of smoke alarms in new housing

Use at least one extra alarm in the living room, wired-in and interconnected to the alarms outside bedroom doors. Consider requiring one alarm in the basement and in each bedroom.

Improve performance of smoke alarms

Make sure alarms are equipped with a timed override switch, which would allow the noise to be turned off for a short period of time in case of false alarm (i.e. 5-10 minutes to allow smoke to clear after something has been burnt in the oven.)

Use battery-operated alarms which are equipped with a visual "low battery" warning device.

Attack the problem of matches directly

Advocate child-proof containers for matches.

Encourage sprinklers in homes designed for people with physical or mental disabilities

Residential homes designed for the physically or mentally disabled should be constructed with sprinkler systems meeting NFPA 13D.

Continue efforts to reduce the cost of residential sprinklers

Encourage research into new materials or technologies to reduce sprinkler costs. Cost has been found to be the most important variable in the cost/benefit studies of sprinklers.

Where sprinkler systems are installed voluntarily, require that they meet NFPA 13D

NFPA 13D sets out the minimum standard for residential sprinkler installations. Lesser installations will not provide the protection people expect.

Address the problem of cooking fires at source

Encourage the use of dedicated extinguishers at the stove.

Improve public education about fire safety

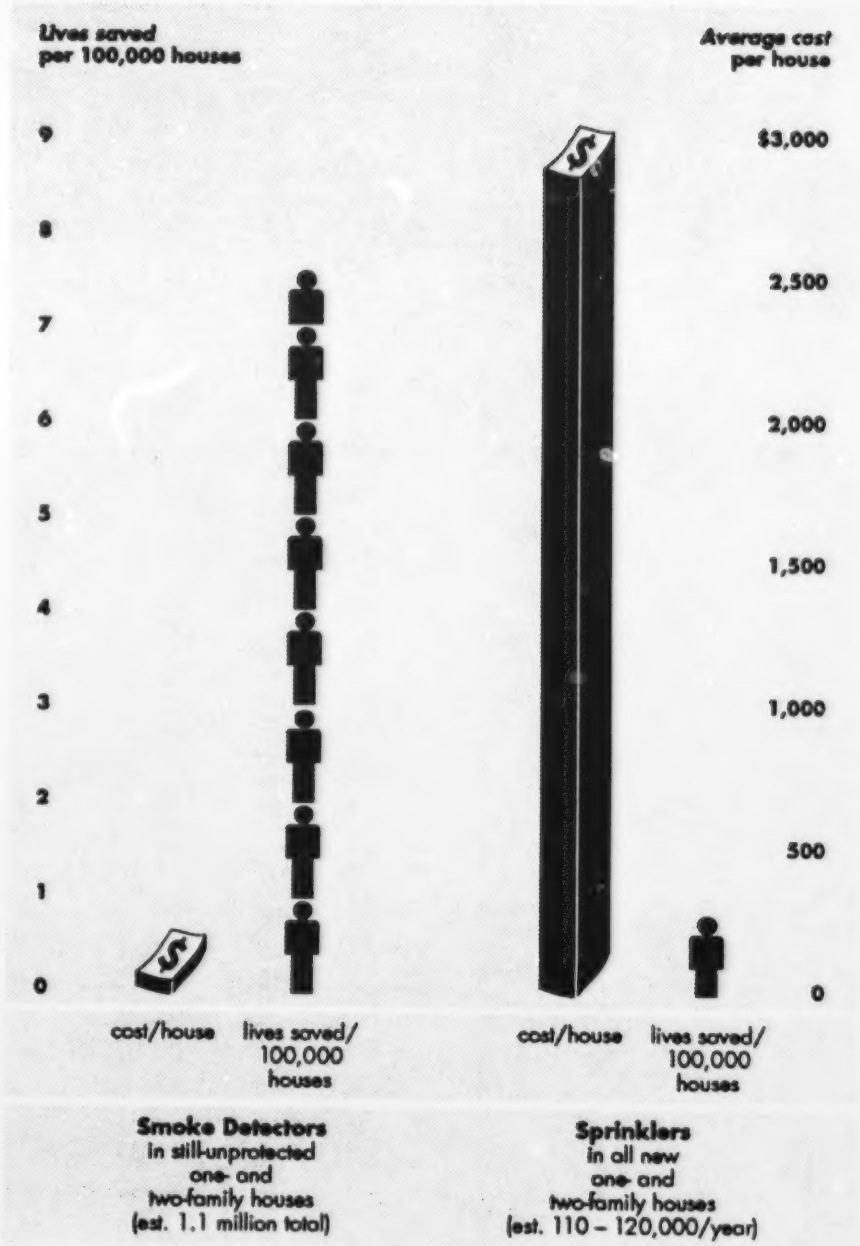
Expand education efforts to reach as many people as possible on the following topics:

- general fire safety
- maintenance of smoke alarms
- maintenance of residential sprinklers
- what to do in case of fire
- escape plans

Consider publicly-funded equipment inspections

Encourage fire, building or property standards inspectors to perform regular maintenance checks on smoke alarms and sprinklers installed in one- and two-family houses.

Impact of Policy Alternatives



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